

THAT WHICH IS CLAIMED:

1. A method for detecting an abnormality in a host medium comprising:
illuminating the host medium at a plurality of different positions;
5 detecting signals following propagation through the host medium and the
abnormality within the host medium;
creating a shadow image based upon the detected signals in which the
abnormality is depicted as a suspicious region;
illuminating at least that portion of the host medium that contains the suspicious
10 region with frequency-swept modulated signals;
detecting the frequency-swept modulated signals following propagation through
at least that portion of the host medium that contains the suspicious region; and
characterizing the abnormality based upon the detected frequency-swept
modulated signals.

2. A method according to Claim 1 wherein said initial illumination step
comprises illuminating the host medium at a plurality of different positions with signals
modulated at a frequency selected from a range of frequencies.

3. A method according to Claim 1 wherein, during said second illumination
step, the signals are frequency-swept modulated across a larger range of frequencies than
the range of frequencies from which the modulation frequency of the signal that initially
illuminates the host medium is selected.

4. A method according to Claim 1 wherein said initial illumination step
comprises illuminating the host medium with signals having at least two different
wavelengths.

5. A method according to Claim 4 wherein said initial detecting step comprises detecting at least an amplitude of the signals following propagation through the host medium and the abnormality within the host medium.

5 6. A method according to Claim 5 further comprising forming a ratio of the amplitude of the signals detected during said initial detecting step at each of the different wavelengths.

7. A method according to Claim 1 wherein said step of illuminating at least that portion of the host medium that contains the suspicious region comprises illuminating at least that portion of the host medium that contains the suspicious region with signals having at least two different wavelengths.

8. A method according to Claim 7 further comprising a step of determining a P-criteria for at least one of a plurality of positions within at least that portion of the host medium that contains the suspicious region following said second detecting step, wherein the P-criteria is at least partially based upon coefficients of absorptivity for signals having the different wavelengths at the respective position.

9. A method according to Claim 1 further comprising a step of determining an S_{var} -criteria for at least one of a plurality of positions within at least that portion of the host medium that contains the suspicious region following said second detecting step, wherein the S_{var} -criteria is at least partially based upon a variation in percent concentration of oxygenated hemoglobin between the abnormality and the host medium and a variation in total hemoglobin concentration between the abnormality and the host medium at the respective position.

10. A method according to Claim 1 wherein said second illuminating step comprises positioning a light source at a position offset from the suspicious region, and wherein said second detecting step comprises moving a detector along a linear path displaced from the suspicious region.

5
11 A method according to Claim 1 wherein said second illuminating step comprises positioning a light source at a position offset from the suspicious region, and wherein said second detecting step comprises moving a detector through a plurality of positions including at least one position aligned with the suspicious region.

12. A method according to Claim 1 wherein said second illuminating and detecting steps comprise:

10 positioning a light source and a detector on opposite sides of the host medium in an offset relation; and
moving the light source and the detector in tandem such that the offset relation is maintained.

15 13. A method according to Claim 1 further comprising:
illuminating a portion of the host medium at a plurality of different positions displaced from the suspicious region with signals having at least two different wavelengths;
detecting the signals following propagation through the host medium; and
determining a reference scattering coefficient and a reference absorption
20 coefficient for the host medium based upon the detected signals.

25 14. A method according to Claim 13 further comprising determining an absorption coefficient and a size of the abnormality based setting a scattering coefficient of the abnormality equal to the reference scattering coefficient and further based upon the frequency-swept modulated signals that are detected following propagation through at least that portion of the host medium that contains the suspicious region.

30 15. A method according to Claim 14 further comprising determining a location of the abnormality within the host medium following said second detecting step.

16. A method according to Claim 1 wherein the host medium is a breast, and wherein the method further comprises compressing the breast between a pair of plates prior to said initial illumination step.

5 17. A method according to Claim 1 wherein the host medium is a breast, and wherein the method further comprises applying oil to the breast prior to said initial illumination step.

10 18. An apparatus for detecting an abnormality in a host medium comprising:
a light source for generating signals that illuminate the host medium at a plurality of different positions;

a modulator for applying frequency-swept modulation to the signals generated by said light source prior to illuminating the host medium;

15 a detector for detecting signals following propagation through the host medium and the abnormality within the host medium;

a display for presenting a shadow image based upon the detected signals in which the abnormality is depicted as a suspicious region; and

20 a positioner for positioning said light source relative to the host medium such that said light source illuminates the host medium at the plurality of different positions, wherein said positioner initially positions said light source at a plurality of different positions that cover a broad portion of the host medium to facilitate generation of the shadow image, and wherein said positioner subsequently positions said light source proximate that portion of the host medium that includes the suspicious region to facilitate characterization of the abnormality.

25 19. An apparatus according to Claim 18 wherein said positioner also positions said detector relative to the host medium, wherein said positioner maintains said light source and said detector in alignment while initially positioning said light source and said detector at a plurality of different positions that cover a broad portion of the host medium
30 to facilitate generation of the shadow image, and wherein said positioner maintains said light source and said detector in an offset relation while subsequently positioning said

light source and said detector proximate that portion of the host medium that includes the suspicious region to facilitate characterization of the abnormality.

5 20. An apparatus according to Claim 18 wherein said positioner comprises at least two X-Y linear motorized stages.

 21. An apparatus according to Claim 18 wherein said modulator comprises a frequency-swept network analyzer.

10 22. An apparatus according to Claim 18 wherein the host medium is a breast, and wherein the apparatus further comprises a pair of plates separated by a distance sufficient to receive the breast of a patient.

15 23. An apparatus according to Claim 22 further comprising an adjustable belt extending between said plates proximate the breast, said adjustable belt capable of being tightened about the breast such that the breast fills a region defined by said pair of plates and said adjustable belt, thereby facilitating imaging of the breast.

20 24. An apparatus according to Claim 22 further comprising an opaque material that fills a region defined by said plates that is unfilled by the breast.

25 25. An apparatus according to Claim 24 further comprising a background light source for illuminating any regions of separation between said opaque material and the breast.

 26. An apparatus according to Claim 22 further comprising a separation detector for measuring the distance by which said pair of plates are separated.

30 27. An apparatus according to Claim 18 wherein said detector is a photomultiplier tube.

28. An apparatus according to Claim 18 further comprising a diaphragm for selectively controlling an intensity of light that is presented to said detector.

29. An apparatus according to Claim 18 wherein said light source comprises a first fiber optic pigtail infrared diode laser capable of emitting signals having a power level of between 100 milliwatts and 500 milliwatts and a wavelength of between 810 nanometers and 840 nanometers.

30. An apparatus according to Claim 29 wherein said light source comprises a second fiber optic pigtail infrared diode laser capable of emitting signals having a power level of between 100 milliwatts and 500 milliwatts and a wavelength of between 670 nanometers and 700 nanometers.

31. An apparatus according to Claim 18 further comprising:
a reference light source for also illuminating the host medium with reference signals;
a reference detector for detecting the reference signals following propagation through the host medium and the abnormality within the host medium; and
a shutter for preventing further detection by said detector if said reference detector detects that an amplitude of the reference signals exceeds a predetermined threshold.

32. An apparatus according to Claim 31 wherein said reference light source comprises a fiber optic pigtail diode laser operating in a continuous wave mode and capable of emitting signals having a wavelength of between 950 nanometers and 980 nanometers.

33. An apparatus for compressing a breast comprising:
a pair of plates separated by a distance sufficient to receive the breast of a patient;
and
an adjustable belt extending between said plates proximate the breast, said adjustable belt capable of being tightened about the breast such that the breast fills a

region defined by said pair of plates and said adjustable belt, thereby facilitating imaging of the breast.

5 34. An apparatus according to Claim 33 further comprising an opaque material that fills that a region defined by said plates that is unfilled by the breast.

10 35. An apparatus according to Claim 34 wherein said adjustable belt is operably connected to said opaque material such that said opaque material is drawn about the breast as said adjustable belt is tightened.

15 36. An apparatus according to Claim 34 further comprising a background light source for illuminating any regions of separation between said opaque material and the breast.

20 37. An apparatus according to Claim 33 further comprising means for controllably positioning at least one of said pair of plates.

25 38. An apparatus according to Claim 33 further comprising a separation detector for measuring the distance by which said pair of plates are separated.

30 39. An apparatus according to Claim 33 wherein said pair of plates are transparent.

35 40. A method for detecting an abnormality in a host medium comprising:
illuminating the host medium at a plurality of different positions;
detecting signals following propagation through the host medium and the abnormality within the host medium;
creating a shadow image based upon the detected signals in which the abnormality is depicted as a suspicious region;

comparing the shadow image to an x-ray image, said comparing step comprising comparing the suspicious region of the shadow image to the x-ray image of the abnormality; and

characterizing the abnormality based upon the comparison of the suspicious
5 region of the shadow image to the x-ray image of the abnormality.

41. A method according to Claim 40 wherein said comparing step comprises overlaying the shadow image onto the x-ray image.

10 42. A method according to Claim 40 wherein said illumination step comprises illuminating the host medium at a plurality of different positions with signals modulated at a frequency selected from a range of frequencies.

15 43. A method according to Claim 40 wherein said illumination step comprises illuminating the host medium with signals having at least two different wavelengths.

20 44. A method according to Claim 43 wherein said detecting step comprises detecting at least an amplitude of the signals following propagation through the host medium and the abnormality within the host medium.

45. A method according to Claim 44 further comprising forming a ratio of the amplitude of the signals detected during said initial detecting step at each of the different wavelengths.

25 46. A method according to Claim 40 wherein the host medium is a breast, and wherein the method further comprises compressing the breast between a pair of plates prior to said illumination step.

30 47. A method according to Claim 40 wherein the host medium is a breast, and wherein the method further comprises applying oil to the breast prior to said illumination step.